

CHAPTER 2: PURPOSE AND NEED FOR DOE ACTION

The Department of Energy (DOE) is proposing to construct and operate a state-of-the-art neutron source to:

- Satisfy the future needs of U.S. researchers in neutron scattering science for a pulsed-neutron source with much higher intensity, more comprehensive instrumentation, better experimental flexibility, and greater potential for future upgrades than offered by existing U.S. facilities.
- Facilitate new scientific discoveries and develop cutting-edge technologies.
- Augment the capabilities of reactor-based neutron sources.

The U.S. needs a high-flux, short-pulsed neutron source to provide the scientific and industrial research communities with a much more intense source of pulsed neutrons for neutron scattering research than is currently available and to assure the availability of a state-of-the-art facility in the decades ahead. This next-generation neutron source would create new scientific and engineering opportunities as well as help replace the capacity that will be lost by the eventual shutdown of existing sources in the first half of the next century as they reach the end of their useful operating lives.

As explained in the preceding chapter, the neutron science community has long recognized the need for both high intensity pulsed (accelerator-based) and continuous (reactor-based) neutron sources. The two types of sources are complementary. For many scattering techniques, having neutrons available in a series of pulses is preferable to having them in a continuous beam. In addition, spallation sources can generally produce pulsed beams with a much higher peak intensity than those available from comparable sized reactor-based sources. This enables scientists to carry out a number of important flux-limited experiments. In recent years, steady improvements in accelerator

technology have made it possible to design and construct sources that can produce even more intense neutron pulses. The proposed SNS, with a proton beam power of 1 MW, would initially produce pulses with a neutron intensity over five times higher than those obtainable from today's best operational spallation source, ISIS in the United Kingdom.

A valuable feature of a pulsed spallation neutron source is the ability to tune the beam of neutrons for particular experiments (the time-of-flight technique). Each pulse of neutrons from the proposed SNS would contain neutrons with a range of energies. The energy level of the neutrons could be determined by noting the length of time it takes for the neutron to travel from the source to the detectors. The high-energy (faster) neutrons would reach the sample ahead of the medium-energy neutrons, and the lowest-energy (slower) neutrons would reach the sample last. Because the neutron energies would be spread out over time, the researcher could tune the neutron beam by selecting the energy level of interest by simply turning the detectors off and on at the appropriate time. Time-of-flight techniques enable the collection of many data points for each pulse of neutrons reaching the sample. Experience has shown that neutron

pulses lasting approximately 1 μ s (one millionth of a second), each with a pulse occurring from 10 to 60 times per second, are optimal (BESAC 1996).

2.1 NEUTRON RESEARCH AND SOURCES

There are approximately 20 major neutron sources worldwide that produce neutron beams for materials research (refer to Table 1.2-1). Although these facilities are primarily located at large government-owned science laboratories, small research teams based at universities, research institutes, and industrial laboratories typically carry out neutron scattering experiments at these centers. The majority of users require recurrent, short-term access to the facilities, often for no more than a few days at a time. The research carried out at these sources contributes to the scientific and technological infrastructure in their regions and also contributes toward their industrial competitiveness.

Based on the conclusions of the OECD Neutron Science Working Group, which has studied this topic since 1996, there is a growing disparity between the worldwide need for neutron scattering research and the availability of facilities (reactor and spallation sources) to meet these needs. It was estimated that as the oldest sources continue to age, only about one-third of the present sources would remain available by 2010. The next generation neutron sources are then needed not only to create new scientific and engineering opportunities, but also to replace out-dated capacity. In the U.S., the shortfall in neutron scattering resources compared with

growing research demand and the lag in experimental capabilities compared with newer and more extensively upgraded foreign facilities have been major concerns for over ten years. As stated most recently in the Kohn and Russell Panel Reports (BESAC 1993, 1996), the present U.S. sources are inadequate to meet the needs of the American scientific community, both in terms of flux and availability. The current generation of neutron sources in the U.S. has lower neutron beam intensities, lower operating powers, and less advanced measuring instruments, when compared to what is currently technologically feasible and desirable.

Given the long lead time from starting conceptual design to the commissioning of a new source (at least 10 years), decisions on new facilities are necessary in the next few years and certainly before 2005. Access to European and Japanese neutron sources by U.S. researchers and manufacturers is difficult, unreliable, and costly. The logistics of scheduling time and configuring instrumentation to conduct specialized experiments are prohibitive because of the commuting distance to these facilities. Because of its proprietary nature, much of the research desired by U.S. industry simply cannot be carried out at foreign facilities.

Scientific discoveries and the new technologies derived from neutron scattering research, as summarized in Chapter 1, have contributed significantly to the development of new products for sale in the international marketplace. Because of the longstanding relationship between basic science and the world of business, scientific and technological advances like these have become major drivers of national economic progress and competitiveness among the

industrialized nations of the world. The same type of relationship has developed between basic science and national defense. Since the end of World War II, the U.S. has used scientific discoveries to develop and sustain military capabilities that surpass those of potential international adversaries. These important relationships will continue into the foreseeable future.

Without future investments in major new science facilities, such as the proposed SNS, the nation's economic strength and competitiveness in the world economy, its national defense posture, and the health of its people may be jeopardized as the newest and best related technological developments are made overseas. The construction of a next-generation spallation neutron source in the U.S. would go far in providing a competitive edge for the nation in the physical, chemical, materials, biological, and medical sciences.

2.2 RELATIONSHIP OF THE SNS PROJECT TO OTHER DOE PROJECTS

DOE proposes to build the SNS to satisfy the nation's need for a world-class pulsed neutron scattering research facility. The projects discussed below, while supporting U.S. neutron scattering science in general, are independent actions. These projects are not related to the proposed SNS, and any decisions involving these projects are independent of the determination of whether or not to build the proposed SNS. The projects are summarized in the following sections.

2.2.1 DESIGN AND CONSTRUCTION OF THE ADVANCED NEUTRON SOURCE

Work on an advanced steady-state neutron source was initiated by ORNL in 1987, and by 1992, a conceptual design was completed for a 330-MW reactor-based Advanced Neutron Source (ANS). Congress did not appropriate construction funding in FY 1994 or FY 1995 for ANS, and DOE chose to cancel the project shortly thereafter, principally due to concerns over the high cost of the facility (approximately \$3 billion). This occurred after public scoping for an Environmental Impact Statement (EIS); however, the EIS was not completed (DOE 1993a; ORNL 1997a).

2.2.2 THE HIGH-FLUX BEAM REACTOR TRANSITION PROJECT

Upgrade of the High-Flux Beam Reactor (HFBR) at Brookhaven National Laboratory (BNL) was recommended by the 1996 BESAC report on neutron facility upgrades.

Shortly afterward (late 1996), HFBR was shut down for a normal refueling, but before the reactor's planned restart, its spent fuel storage pool was identified as the likely source of elevated tritium concentrations in the groundwater at BNL. The reactor has remained shut down in a defueled condition, and DOE has initiated a Tritium Remediation Project that will continue to prevent the tritium plume from spreading off-site.

DOE has published a Notice of Intent to prepare an EIS concerning the HFBR. The alternatives being considered in the HFBR EIS include the following:

- No Action Alternative (maintain present shutdown, defueled condition)
- Resume Operation Alternative
- Resume Operation and Enhance Facility Alternative
- Permanent Shutdown Alternative

2.2.3 UPGRADE THE HIGH-FLUX ISOTOPE REACTOR

The 1996 BESAC recommended extensive upgrades to the High-Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL). These upgrades include development of an internationally competitive cold neutron scattering facility; establishment of premier thermal neutron capabilities; and improvement of isotope production, materials irradiation facilities, and neutron activation analysis capabilities (DOE 1996b).

DOE determined that the HFIR upgrades are categorically excluded from environmental review under NEPA, and these upgrades are being implemented. These upgrades include modifications of test facilities to perform research, development, and experimental testing using the existing beam lines and added cold neutron source capabilities.

2.2.4 INSTITUTE FOR NEUTRON SCIENCE

ORNL and The University of Tennessee (UT) are collaborating on establishing the Joint Institute for Neutron Science (JINS). This proposed facility is being funded by the state of Tennessee and would provide overnight accommodations, as well as meeting rooms and lecture halls, for scientists visiting the neutron science facilities at ORNL. The JINS is not part of the proposed action in this EIS; it will be built regardless of which alternative action is taken for the proposed SNS. This facility is currently being designed by the Division of Facilities Planning at UT. Construction is expected to begin in the summer of 1999 with occupancy in the summer of 2000. The JINS is to be constructed on the Oak Ridge Reservation (ORR), at a location across from the ORNL 7000 area on Bethel Valley Road. DOE will lease the land for JINS to UT; therefore, DOE will complete the appropriate National Environmental Policy Act (NEPA) documentation prior to commitment of the land to this facility.